ENERGY STAR® PortfolioManager®

ENERGY STAR Score for Medical Offices in the United States

OVERVIEW

The ENERGY STAR Score for Medical Offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. The objective of the ENERGY STAR score is to provide a fair assessment of the energy performance of a property relative to its peers, taking into account the climate, weather, and business activities at the property. To identify the aspects of building activity that are significant drivers of energy use and then normalize for those factors, a statistical analysis of the peer building population is performed. The result of this analysis is an equation that will predict the energy use of a property, based on its experienced business activities. The energy use prediction for a building is compared to its actual energy use to yield a 1 to 100 percentile ranking of performance, relative to the national population.

- **Property Types.** The ENERGY STAR score for medical offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. The score applies to individual buildings only and is not available for campuses.
- **Reference Data.** The analysis for medical offices is based on data from the Department of Energy, Energy Information Administration's 1999 Commercial Building Energy Consumption Survey (CBECS).
- **Adjustments for Weather and Business Activity.** The analysis includes adjustments for:
  - Square Footage
  - Number of Workers
  - Hours of Operation per Week
  - Weather and Climate (using Heating and Cooling Degree Days, retrieved based on Zip code)
  - Percent of the Building that is Heated and Cooled
- **Release Date.** The ENERGY STAR score for medical offices was released in February 2004.

This document presents details on the development of the 1 - 100 ENERGY STAR score for medical office properties. More information on the overall approach to develop ENERGY STAR scores is covered in our Technical Reference for the ENERGY STAR Score, available at www.energystar.gov/ENERGYSTARScore. The subsequent sections of this document offer specific details on the development of the ENERGY STAR score for medical offices:

REFERENCE DATA & FILTERS

For the ENERGY STAR score for medical offices properties, the reference data used to establish the peer building population in the United States is based on data from the Department of Energy, Energy Information Administration's (EIA) 1999 Commercial Building Energy Consumption Survey (CBECS). Detailed information on this survey, including complete data files, is available at: http://www.eia.doe.gov/emeu/cbecs/contents.html.

To analyze the building energy and operating characteristics in this survey data, four types of filters are applied to define the peer group for comparison and to overcome any technical limitations in the data: Building Type Filters, Program Filters, Data Limitation Filters, and Analytical Filters. A complete description of each of these categories is provided in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore. *Figure 1* presents a summary of each filter applied in the development of the ENERGY STAR score for medical offices and the rationale behind the filter. After all filters are applied, the remaining data set has 82 properties.

Figure 1 – Summary of Filters for the ENERGY STAR Score for Medical Offices

Condition for Including an Observation in the Analysis	Rationale
PBAPLUS7= 8	Building Type Filter – CBECS defines building types according to the variable "PBAPLUS7." Medical Office Buildings are coded as PBAPLUS7= 8.
Must operate for at least 30 hours per week	Program Filter – Baseline condition for being a full time medical office building.
Must have at least 1 worker	Program Filter – Baseline condition for being a full time medical office building.
Source energy use intensity (kBtu/ft^2-yr) must be greater than 38 and less than 575 kBtu/ft^2-yr	Analytical Filter – Values determined to be statistical outliers.
Must have square foot of at least 5,000	Analytical Filter – Values determined to be statistical outliers.

Of the filters applied to the reference data, some result in constraints on calculating a score in Portfolio Manager and others do not. Building Type and Program Filters are used to limit the reference data to include only properties that are eligible to receive a score in Portfolio Manager, and are therefore related to eligibility requirements. In contrast, Data Limitation Filters account for limitations in the data availability, but do not apply in Portfolio Manager. Analytical Filters are used to eliminate outlier data points or different subsets of data, and may or may not affect eligibility. In some cases, a subset of the data will have different behavior from the rest of the properties (e.g., medical office buildings smaller than 5,000 ft^2 do not behave the same way as larger buildings), in which case an Analytical Filter will be used to determine eligibility in Portfolio Manager. In other cases, Analytical Filters exclude a small number of outliers with extreme values that skew the analysis, but do not affect eligibility requirements. A full description of the criteria you must meet to get a score in Portfolio Manager is available at www.energystar.gov/EligibilityCriteria.

Related to the filters and eligibility criteria described above, another consideration is how Portfolio Manager treats properties that are situated on a campus. The main unit for benchmarking in Portfolio Manager is the property, which

may be used to describe either a single building or a campus of buildings. The applicability of the ENERGY STAR score depends on the type of property. For medical office properties, the score is based on individual buildings, because the primary function of the medical office is contained within a single building and because the properties included in the reference data are single buildings. In cases where multiple medical offices are situated together (e.g., as part of a hospital campus), each individual building can receive its own ENERGY STAR score, but a group of buildings together cannot earn a score.

VARIABLES ANALYZED

To normalize for differences in business activity, we perform a statistical analysis to understand what aspects of building activity are significant with respect to energy use. The filtered reference data set described in the previous section is analyzed using a weighted ordinary least squares regression, which evaluates energy use relative to business activity (e.g., number of workers, operating hours per week). This linear regression yields an equation that is used to compute energy use (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables). This section details the variables used in the statistical analysis for medical offices.

Dependent Variable

The dependent variable is what we try to predict with the regression equation. For the medical office analysis, the dependent variable is energy consumption expressed as the natural log of source energy use, or Ln (source energy). The regressions analyze the key drivers of Ln (source energy) – those factors that explain the variation in the natural log of source energy in medical offices.

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for medical offices. These include characteristics such as the total square foot, the weekly hours of operation, the number of workers, the percent of the building that is heated and cooled, and the number of heating and cooling degree days.

We perform extensive review on all operational characteristics available in the data, in accordance with the criteria for inclusion in Portfolio Manager[1]. In addition to reviewing each characteristic individually, characteristics are reviewed in combination with each other (e.g., Heating Degree Days times Percent Heated). As part of the analysis, some variables are reformatted to reflect the physical relationships of building components. For example, the number of workers on the main shift is typically evaluated in a density format. The number of workers *per square foot* (not the gross number of workers) is expected to be correlated with the energy use per square foot. In addition, based on analytical results and residual plots, variables are examined using different transformations (such as the natural logarithm). The analysis consists of multiple regression formulations. These analyses are structured to find the combination of statistically significant operating characteristics that explain the greatest amount of variance in the dependent variable: Ln (source energy).

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[1] For a complete explanation of these criteria, refer to our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

The final regression equation includes the following variables:

- Natural log of gross square foot
- Natural log of number of workers
- Natural log of weekly operating hours
- Heating degree days times Percent of the building that is heated
- Cooling degree days times Percent of the building that is cooled

These variables are used together to compute the predicted Ln (source energy) for medical offices. The predicted Ln (source energy) is the mean Ln (source energy) for a hypothetical population of buildings that share the same values for each of these variables. That is, the mean energy use for a building that operates just like your building.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 82 observations. The dependent variable is Ln (source energy). Each independent variable is presented in *Figure 2*. The final equation is presented in *Figure 3*. All variables in the regression equation are significant at the 95% confidence level or better, as shown by the significance levels (a p-level of less than 0.05 indicates 95% confidence), with the exception of weekly operating hours and HDD times percent heated (88% and 84%, respectively). However, given the physical relationship between these variables and energy consumption, these results were considered acceptable, and therefore both weekly operating hours and HDD times percent heated were retained in the analysis.

The regression equation has a coefficient of determination (R^2) value of 0.934, indicating that this equation explains 93.4% of the variance in Ln (source energy) for medical office buildings. This is an excellent result for a statistically based energy model.

Detailed information on the ordinary least squares regression approach is available in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

Figure 2 - Descriptive Statistics for Variables in Final Regression Equation

Variable	Mean	Minimum	Maximum
Ln (Source Energy) (kBtu)	14.919	11.344	18.878
Ln (Square Foot)	9.856	6.908	13.122
Ln (Number of Workers)	3.840	0.693	7.718
Ln (Weekly Operating Hours)	3.937	3.555	4.820
Heating Degree Days x Percent Heated	3692	0.000	8176
Cooling Degree Days x Percent Cooled	1253	54	4143

Figure 3 - Final Regression Results

Summary				
Dependent Variable	Ln (Source Energy)			
Number of Observations in Analysis	82			
R^2 value	0.9336			
F Statistic	213.6			
Significance (p-level)	<0.0001			
	Unstandardized Coefficients	**Standard Error**	**T value**	**Significance (p-level)**
Constant	2.78889	1.19393	2.34	0.0221
Ln (Square Foot)	0.91433	0.09998	9.14	0.0001
Ln (Number of Workers)	0.21568	0.09332	2.31	0.0235
Ln (Weekly Operating Hours)	0.46768	0.29816	1.57	0.1209
Heating Degree Days x Percent Heated	0.00005321	0.00003712	1.43	0.1558
Cooling Degree Days x Percent Cooled	0.00020111	0.00007429	2.71	0.0084

Notes:
- *The regression is a weighted ordinary least squares regression, weighted by the CBECS variable "ADJWT8".*

ENERGY STAR SCORE LOOKUP TABLE

The final regression equation (presented in **Figure 3**) yields a prediction of Ln (source energy) based on a building's operating characteristics. Some buildings in the reference data sample use more energy than predicted by the regression equation, while others use less. The *actual* Ln (source energy) of each reference data observation is divided by its *predicted* Ln (source energy) to calculate an energy efficiency ratio:

$$Energy\ Efficiency\ Ratio = \frac{Actual\ Ln\ (Source\ energy)}{Predicted\ Ln\ (Source\ energy)}$$

A lower efficiency ratio indicates that a building uses less energy than predicted, and consequently is more efficient. A higher efficiency ratio indicates the opposite. For each building, the ratio is expressed in terms of a normalized Ln (source energy) to represent the value for Ln (source energy) that the building would have if it were average. This normalized energy use is obtained by multiplying the efficiency ratio by the mean value of Ln (source energy):[2]

$$Normalized\ Ln\ (Source\ Energy) = Energy\ Efficiency\ Ratio \times 14.919$$

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[2] The mean value of Ln (source energy) is determined by the dataset and is presented in **Figure 2**. It is 14.919.

The normalized Ln (source energy) values are sorted from smallest to largest and the cumulative percent of the population at each energy value is computed. A smooth curve is fitted to the data using a two parameter gamma distribution. The fit is performed in order to minimize the sum of squared differences between each building's actual percent rank in the population and each building's percent rank with the gamma solution. The fit is performed with the constraint that the gamma value of Ln (source energy) at an ENERGY STAR score of 75 must equal the actual value of Ln (source energy) at 75.

The final gamma shape and scale parameters are used to calculate the normalized Ln (source energy) value at each percentile (1 to 100) along the curve. For example, the normalized Ln (source energy) value on the gamma curve at 1% corresponds to a score of 99; only 1% of the population has a value this small or smaller. The normalized Ln (source energy) value on the gamma curve at the value of 25% will correspond to the normalized Ln (source energy) value for a score of 75; only 25% of the population has normalized Ln (source energy) values this small or smaller. The complete lookup table is presented in *Figure 4*.

Figure 4 – ENERGY STAR Score Lookup Table for Medical Offices

ENERGY STAR Score	Cumulative Percent	Normalized Ln (Source Energy)		ENERGY STAR Score	Cumulative Percent	Normalized Ln (Source Energy)	
		> =	<			>=	<
100	0%	0.0000	13.8263	50	50%	15.0463	15.0583
99	1%	13.8263	13.8843	49	51%	15.0583	15.0703
98	2%	13.8843	13.9403	48	52%	15.0703	15.0813
97	3%	13.9403	13.9923	47	53%	15.0813	15.0923
96	4%	13.9923	14.0423	46	54%	15.0923	15.1023
95	5%	14.0423	14.0893	45	55%	15.1023	15.1133
94	6%	14.0893	14.1333	44	56%	15.1133	15.1233
93	7%	14.1333	14.1753	43	57%	15.1233	15.1323
92	8%	14.1753	14.2153	42	58%	15.1323	15.1423
91	9%	14.2153	14.2523	41	59%	15.1423	15.1513
90	10%	14.2523	14.2883	40	60%	15.1513	15.1593
89	11%	14.2883	14.3223	39	61%	15.1593	15.1683
88	12%	14.3223	14.3553	38	62%	15.1683	15.1763
87	13%	14.3553	14.3863	37	63%	15.1763	15.1843
86	14%	14.3863	14.4153	36	64%	15.1843	15.1913
85	15%	14.4153	14.4443	35	65%	15.1913	15.1993
84	16%	14.4443	14.4713	34	66%	15.1993	15.2063
83	17%	14.4713	14.4973	33	67%	15.2063	15.2133
82	18%	14.4973	14.5223	32	68%	15.2133	15.2203
81	19%	14.5223	14.5463	31	69%	15.2203	15.2273
80	20%	14.5463	14.5693	30	70%	15.2273	15.2343
79	21%	14.5693	14.5923	29	71%	15.2343	15.2413
78	22%	14.5923	14.6133	28	72%	15.2413	15.2483
77	23%	14.6133	14.6353	27	73%	15.2483	15.2553
76	24%	14.6353	14.6553	26	74%	15.2553	15.2633
75	25%	14.6553	14.6753	25	75%	15.2633	15.2703
74	26%	14.6753	14.6943	24	76%	15.2703	15.2783
73	27%	14.6943	14.7133	23	77%	15.2783	15.2863
72	28%	14.7133	14.7323	22	78%	15.2863	15.2953
71	29%	14.7323	14.7503	21	79%	15.2953	15.3053
70	30%	14.7503	14.7673	20	80%	15.3053	15.3153
69	31%	14.7673	14.7853	19	81%	15.3153	15.3263
68	32%	14.7853	14.8023	18	82%	15.3263	15.3383
67	33%	14.8023	14.8183	17	83%	15.3383	15.3503
66	34%	14.8183	14.8353	16	84%	15.3503	15.3643
65	35%	14.8353	14.8513	15	85%	15.3643	15.3803
64	36%	14.8513	14.8663	14	86%	15.3803	15.3963
63	37%	14.8663	14.8823	13	87%	15.3963	15.4153
62	38%	14.8823	14.8973	12	88%	15.4153	15.4353
61	39%	14.8973	14.9123	11	89%	15.4353	15.4563
60	40%	14.9123	14.9273	10	90%	15.4563	15.4803
59	41%	14.9273	14.9413	9	91%	15.4803	15.5073
58	42%	14.9413	14.9553	8	92%	15.5073	15.5353
57	43%	14.9553	14.9693	7	93%	15.5353	15.5663
56	44%	14.9693	14.9833	6	94%	15.5663	15.6013
55	45%	14.9833	14.9963	5	95%	15.6013	15.6383
54	46%	14.9963	15.0093	4	96%	15.6383	15.6783
53	47%	15.0093	15.0223	3	97%	15.6783	15.7223
52	48%	15.0223	15.0343	2	98%	15.7223	15.7703
51	49%	15.0343	15.0463	1	99%	15.7703	>15.7703

EXAMPLE CALCULATION

As detailed in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore, there are five steps to compute a score. The following is a specific example for the score for medical offices:

1   User enters building data into Portfolio Manager

- 12 months of energy use information for all energy types (annual values, entered in monthly meter entries)
- Physical building information (size, location, etc.) and use details describing building activity (hours, etc.)

Energy Data	Value
Electricity	123,400 kWh
Natural gas	2,000 therms

Property Use Details	Value
Gross floor area (ft^2)	14,000
Weekly operating hours	50
Workers on the main shift[3]	25
Percent of the building that is heated	100%
Percent of the building that is cooled	100%
HDD (provided by Portfolio Manager, based on Zip code)	4200
CDD (provided by Portfolio Manager, based on Zip code)	1200

2   Portfolio Manager computes the actual Ln (source energy)

- Total energy consumption for each fuel is converted from billing units into site energy and source energy
- Source energy values are added across all fuel types
- The natural log of total source energy consumption is computed

Computing Actual Ln (Source Energy)

Fuel	Billing Units	Site kBtu Multiplier	Site kBtu	Source kBtu Multiplier	Source kBtu
Electricity	123,400 kWh	3.412	421,041	3.14	1,322,068
Natural gas	2,000 therms	100	200,000	1.05	210,000
				Total Source Energy (kBtu)	1,532,068
				Actual Ln (Source Energy) (kBtu)	**14.242**

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[3] This represents typical peak staffing level during the main shift. For example, in a medical office if there are two daily 8 hour shifts of 100 workers each, the Workers on Main Shift value is 100.

| **3** | Portfolio Manager computes the predicted source Ln (source energy) |

- Using the property use details from Step 1, Portfolio Manager computes each building variable value in the regression equation (determining the natural log or density as necessary).
- The variables are multiplied by the coefficients from the regression equation to obtain a predicted Ln (source energy).

Computing Predicted Ln (Source Energy)

Variable	Actual Building Value	Coefficient	Coefficient * Variable
Constant	--	2.789	2.789
Ln (Square Foot)	9.547	0.9143	8.729
Ln (Number of Workers)	3.219	0.2157	0.694
Ln (Weekly Operating Hours)	3.912	0.4677	1.830
HDD x Percent Heated	4200	0.00005	0.223
CDD x Percent Cooled	1200	0.0002	0.241
	Predicted Ln (source energy) (kBtu)		**14.506**

| **4** | Portfolio Manager computes the energy efficiency ratio |

- The ratio equals the actual Ln (source energy) (Step 2) divided by predicted Ln (source energy) (Step 3)
- Ratio = 14.242 / 14.506 = 0.9818

| **5** | Portfolio Manager uses the efficiency ratio to assign a score via a lookup table |

- The ratio from Step 4 is converted into normalized Ln (source energy)
  - Normalized Ln (source energy) = energy efficiency ratio * mean Ln (source energy)
  - Mean Ln (source energy) is provided in *Figure 2* = 14.919
  - Normalized Ln (source energy) = 0.9818 * 14.919 = 14.647
- This value is then then used to identify the score from the lookup table
- A normalized value of 14.647 is greater than 14.6353 and less than 14.6553.
- *The ENERGY STAR score is 76.*